DESCRIPTION

EXTENSIBLE NONWOVEN FABRIC AND

COMPOSITE NONWOVEN FABRIC COMPRISING THE SAME

5

TECHNICAL FIELD

The present invention relates to an extensible nonwoven fabric. More particularly, the invention relates to an extensible nonwoven fabric which is capable of extension during mechanical stretching, has excellent fuzz resistance,

10 surface abrasion resistance, formability and productivity, and can be heat-embossed at low temperatures. The invention also relates to a composite nonwoven fabric produced by laminating the nonwoven fabric and to a disposable diaper

15 comprising the nonwoven fabric.

BACKGROUND OF THE INVENTION

Nonwoven fabrics have wide applications including clothes, disposable diapers and personal hygiene products.

20 The nonwoven fabrics for such applications are required to have excellent properties, such as touch, conformability to the body, conformity during body movements, drape, tensile strength and surface abrasion resistance.

Traditional nonwoven fabrics made from a monocomponent

fiber, while being resistant to fuzzing and comfortable to the touch, are unsatisfactory in extensibility. Accordingly, there has been a difficulty in using such nonwoven fabrics in diapers and the like where both comfortable touch and good

5 extensibility are required.

It has been believed that the nonwoven fabrics are desirably imparted with elastic properties in order to meet the above requirements, and various methods have been proposed for imparting elastic properties. For example, mechanical

10 stretching of composite nonwoven fabrics that include at least one elastic layer and at least one substantially inelastic layer can produce elastic properties. However, the composite nonwoven fabrics by this method have problems in that the inelastic fiber is damaged or broken during the mechanical

15 stretching to produce fuzz and the fabric strength is lowered.

In consideration of such problems, studies have been being carried out in order to impart high extensibility to the inelastic fibers. For example, JP-A-9/512313 and WO 01/49905 propose composite nonwoven fabrics that comprise multipolymer

20 fibers containing two or more different polymers as the inelastic fibers. The multipolymer fibers contained in the composite nonwoven fabrics have achieved high extensibility. However, the composite nonwoven fabrics according to the teachings of these publications suffer fuzzing and have

inferior touch.

OBJECT OF THE INVENTION

It is an object of the present invention to provide an

5   extensible nonwoven fabric which is excellent in strength,

extensibility, fuzz resistance, surface abrasion resistance,

formability and productivity and which can be heat—embossed

at low temperatures. It is another object of the invention

to provide a composite nonwoven fabric produced by laminating

10   the extensible nonwoven fabric.

DISCLOSURE OF THE INVENTION

The present inventors earnestly studied with a view to

solving the aforesaid problems. As a result, they have found

15   that a fiber that comprises olefin-based polymers of the same

kind having different induction periods of strain-induced

crystallization at the same temperature can exhibit high

extensibility.   The present invention has been completed based

on this finding.

20   The extensible nonwoven fabric according to the

invention comprises a fiber comprising at least two

olefin-based polymers, these at least two olefin-based

polymers being of the same kind and having different induction

periods of strain-induced crystallization as measured at the

same temperature and the same shear strain rate.

Preferably, the fiber is a conjugate fiber having a cross section in which a component in point (a) and a component in point (b) which is symmetric about the center point are the

5   same.

Preferably, the extensible nonwoven fabric is a spunbonded nonwoven fabric.

Preferably, the extensible nonwoven fabric has an extensibility at a maximum load of not less than 70% in the

10   machine direction (MD) and/or in the cross machine direction (CD).

Preferably, the olefin-based polymer is a propylene-based polymer.

The composite nonwoven fabric according to the invention

15   comprises at least one layer comprising the extensible nonwoven fabric as described above. The disposable diaper of the invention includes the extensible nonwoven fabric as described above.

20   **BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 is a graph showing changes in melt shear viscosity measured in the invention with time;

Fig. 2 is a sectional view of a fiber used in the invention, in which the referential number 1 indicates the center point

of cross section;

Fig. 3 is a set of sectional views of a conjugate fiber used in the invention, in which (a) shows a cross section of concentric sheath-core configuration, (b) shows a cross

5 section of side-by-side configuration and (c) shows a cross section of islands-in-the-sea configuration, wherein the referential numbers 2 denotes a core portion, 3 denotes a sheath portion, 4 denotes a first component and 5 denotes a second component;

10 Fig. 4 is a schematic view illustrating stretching gears;

Fig. 5 is a stress-strain curve obtained by a tensile test for composite nonwoven fabrics resulting in Examples; and

Fig. 6 is a stress-strain curve obtained by a tensile retest for the composite nonwoven fabrics illustrated in Fig.

15 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The extensible nonwoven fabric and the composite nonwoven fabric produced by laminating the same according to

20 the invention will be described hereinbelow.

<Extensible nonwoven fabric>

(Induction period of strain-induced crystallization)

First, the "induction period of strain-induced crystallization" used in the specification will be described.

The induction period of strain-induced crystallization refers
to a time from when a melt shear viscosity of a polymer starts
to be measured at a constant measurement temperature and a fixed
shear strain rate till when the viscosity begins to increase.

5   Specifically, it is a time t_i illustrated in Fig. 1. That is,
it denotes a time from the start of the measurement till when
the melt shear viscosity that has been constant changes
(increases).

Melt shear viscometers for use in the measurement of the

10 melt shear viscosity include rotational rheometers and
capillary rheometers. The shear strain rate is preferably 3
rad/s or less in view of maintaining a stable flow when the
crystallization has occurred to some extent.

The flow field in a practical spinning is different from

15 that in the above measurement, and the strain rate is very high.
The strain-induced crystallization of a polymer occurs when
the total strain in the system has reached a certain level.
Therefore, the induction period of strain-induced
crystallization is in inverse proportion to the shear strain

20 rate, and the induction period of strain-induced
crystallization at a high shear strain rate can be estimated
from the induction period at a lower shear strain rate.
Similarity between the flow field in the spinning and that in
the above measurement is that polymer molecules are oriented

by the flow. Therefore, it could be possible to estimate the

phenomenon in the elongational flow filed in the practical

spinning based on the results obtained at a lower shear strain

rate.

5   The induction period of strain-induced crystallization

will be measured at a temperature not lower than the static

crystallization temperature, and preferably at between the

static crystallization temperature and the equilibrium

melting point. The measurement temperature is not

10 particularly limited as long as the induction periods of

strain-induced crystallization of the polymers used can be

compared at the temperature, that is, the difference in

induction periods of strain-induced crystallization among the

polymers can be distinct. Preferably, the induction periods

15 of strain-induced crystallization are compared at the highest

of the temperatures at which the resulting induction periods

of strain-induced crystallization are comparable. The

induction periods of strain-induced crystallization will be

preferably different from each other by 50 seconds or longer,

20 and more preferably by 100 seconds or longer. The greater the

difference, the more remarkable the effect of the invention.

Whether or not the induction periods of strain-induced

crystallization will differ from each other may be assumed

based on the differences of the melt flow rates (MFR) and of

the melting points measured under the same conditions. Specifically, the polymers having different induction periods of strain-induced crystallization can be the following combinations (i) to (iii):

5   (i) Polymers having different MFR and different melting points;

(ii) Polymers having the same MFR and different melting points;

(iii) Polymers having different MFR and the same melting
10 point.

Polymers with the same MFR and the same melting point have the same induction period of strain-induced crystallization.

<Olefin-based polymer>

15   The olefin-based polymers for use in the invention include α-olefin homopolymers and copolymers. Preferably, the olefin-based polymers will be ethylene or propylene homopolymers, or copolymers of propylene and at least one α-olefin selected from α-olefins other than the propylene
20 (hereinafter the "propylene copolymers"). The ethylene or propylene homopolymers are more preferable. Particularly preferred are the propylene homopolymers from the viewpoint of preventing fuzzing, and thus they are suitably used in disposable diapers.

The α-olefins other than propylene include ethylene and α-olefins of 4 to 20 carbon atoms. Of these, ethylene and α-olefins of 4 to 8 carbon atoms are preferable, and ethylene, 1-butene, 1-pentene, 1-hexene, 1-octene and

5 4-methyl-1-pentene are more preferable.

The "olefin-based polymers of the same kind" as used in the invention will be defined in the following (1) to (3). The descriptions in (1) and (2) explain the cases where the olefin-based polymers are single polymers, and the description in (3) is for the case where the olefin-based polymers are

10 blends of two or more olefin-based polymers.

(1) Olefin-based homopolymers

As used herein, the "homopolymer" will refer to a polymer containing 90% or more of a main structural unit. That is,

15 a polypropylene containing an ethylene unit in an amount of less than 10% may be considered as a homopolypropylene. Accordingly, the expression "homopolymers of the same kind" means that they are, for example, all polyethylenes or all polypropylenes that may contain a minor structural unit in an

20 amount of less than 10%.

(2) Olefin-based copolymers

The expression "copolymers of the same kind" means that all the copolymers have the same combination of structural units and that the proportional difference of each

corresponding structural units is less than 10% among the

copolymers. For example, an ethylene/propylene copolymer

containing 80% propylene unit and 20% ethylene unit is of the

same kind as an ethylene/propylene copolymer in which the

5   propylene unit is more than 70% and less than 90% and the

ethylene unit is more than 10% and less than 30%.

(3) Blends of olefin-based polymers.

In the invention, a blend comprising two or more polymers

selected from the aforesaid homopolymers and copolymers may

10 be used as an olefin-based polymer. These two or more polymers

to be mixed together may be of the same or different kind. As

used in the invention, the expression "polymer blends of the

same kind" means that all the polymer blends have the same

combination of polymer kinds and that the proportional

15 difference of each corresponding polymers is less than 10%

among the polymer blends. For example, a polymer blend

containing 80 wt% polypropylene and 20 wt% polyethylene is of

the same kind as a polymer blend in which the polypropylene

content is more than 70 wt% and less than 90 wt% and the

20 polyethylene content is more than 10 wt% and less than 30 wt%.

The polyethylene for use in the invention will preferably

range in MFR, as measured at 190°C under a load of 2.16kg in

accordance with ASTM D-1238, from 1 to 100 g/10 min, more

preferably from 5 to 90 g/10 min, and particularly preferably

from 10 to 85 g/10 min.   Also preferably, the polyethylene will

have an Mw/Mn ratio (Mw: weight-average molecular weight, Mn:

number-average molecular weight) of 1.5 to 5.   When the Mw/Mn

ratio is within the above range, the fiber will be beautifully

5   spun and the resultant fiber will have an excellent strength.

As used herein, the "beautifully spinning " means that the resin

can be extruded from a spinneret and drawn without filament

breaking and the filament will not weld.   In the invention,

the weight-average molecular weight (Mw) and the

10   number-average molecular weight (Mn) are the values in terms

of polystyrene determined by a gel permeation chromatography

(GPC) under the conditions of:

        Column: two TSKgel GMH6HT columns and two TSKgel GMH6-HTL

columns

15   Column temperature: 140°C

        Mobile phase: o-dichlorobenzene (ODCB)

        Flow rate: 1.0 mL/min

        Sample concentration: 30 mg/20 mL ODCB

        Injection amount: 500 μL

20   The analysis sample is prepared by dissolving 30mg of

a sample in 20mL of o-dichlorobenzene by heating them at 145°C

for 2 hours, and filtering the resultant solution through a

sintered filter having 0.45μm pores.

        The polypropylene generally has an equilibrium melting

point of 185 to 195°C when its ethylene unit content is 0 %.
The polypropylene for use in the invention will preferably
range in MFR, as measured at 230°C under a load of 2.16kg in
accordance with ASTM D-1238, from 1 to 200 g/10 min, more

5   preferably from 5 to 120 g/10 min, and particularly preferably
from 10 to 100 g/10 min. Also preferably, the polypropylene
will have an Mw/Mn ratio (Mw: weight-average molecular weight,
Mn: number-average molecular weight) of 1.5 to 5.0, and more
preferably 1.5 to 3.0. When the Mw/Mn ratio is within the above

10   range, the fiber will be beautifully spun and the resultant
fiber will have an excellent strength.

The at least two olefin-based polymers for use in the
invention are prepared separately. Preferably, they are
produced into pellets. When two or more kinds of polymers are

15   used in one olefin-based polymer, they are preferably mixed
together in a molten state and pelletized according to
necessity.

<Additives>

In the invention, additives may be optionally used with

20   the olefin-based polymers so long as the objects of the
invention are not impaired. The additives include various
stabilizers, such as heat stabilizers and weathering
stabilizers, fillers, antistatic agents, hydrophilizing
agents, slip agents, anti-blocking agents, anti-fogging

agents, lubricants, dyes, pigments, natural oils, synthetic

oils and waxes.

Exemplary stabilizers include anti-aging agents such as

2,6-di-t-butyl-4-methylphenol (BHT); phenol-based

5   antioxidants such as tetrakis[methylene-3-(3,5-di-t-butyl-

4-hydroxyphenyl)propionate]methane, β-(3,5-di-t-butyl-

4-hydroxyphenyl) propionic acid alkyl ester,

2,2'-oxamidobis[ethyl-3-(3,5-di-t-butyl-4-hydroxyphenyl)]

propionate and Irganox 1010 (trade name, hindered phenol type

10 antioxidant); fatty acid metal salts such as zinc stearate,

calcium stearate and calcium 1,2-hydroxystearate; and fatty

acid esters of polyvalent alcohols such as glycerin

monostearate, glycerin distearate, pentaerythritol

monostearate, pentaerythritol distearate and pentaerythritol

15 tristearate. These stabilizers may be used singly or in

combination of two or more kinds.

Exemplary fillers include silica, diatomaceous earth,

alumina, titanium oxide, magnesium oxide, pumice powder,

pumice balloon, aluminum hydroxide, magnesium hydroxide,

20 basic magnesium carbonate, dolomite, calcium sulfate,

potassium titanate, barium sulfate, calcium sulfite, talc,

clay, mica, asbestos, calcium silicate, montmorillonite,

bentonite, graphite, aluminum powder and molybdenum sulfide.

Preferably, the additives will be used in a mixed

condition with the olefin-based polymers. The additives may

be mixed with one or more of the olefin-based polymers. The

mixing method is not particularly limited and may be a

traditional process.

5 **<Fiber>**

The fiber for use in the invention comprises at least

two olefin-based polymers as described hereinabove. These two

or more olefin-based polymers are of the same kind and have

different induction periods of strain-induced crystallization

10 as measured at the same temperature and the same shear strain

rate. The fiber has substantially no crimps. By "having

substantially no crimps", it is meant that the crimps of the

fiber constituting the nonwoven fabric do not influence the

extensibility of the nonwoven fabric.

15 The fiber is a conjugate fiber and, as illustrated in

Fig. 2, preferably has a cross section in which the polymer

component in point (a) and the polymer component in point (b)

which is symmetric about the center point are the same. As

used herein, the "conjugate fiber" will refer to a monofilament

20 in which there are at least two phases that have a

length/diameter ratio appropriate to be called as a fiber phase.

Here, the diameter will be considered as of the cross section

of fiber regarded as a circle. That is, the conjugate fiber

used in the invention is a monofilament which contains at least

two fiber phases comprising the olefin-based polymers that are of the same kind and have different induction periods of strain-induced crystallization.

The conjugate fiber may have a sheath-core configuration,
5   a side-by-side configuration or an islands-in-the-sea configuration across its cross section. Specifically, the sheath-core conjugate fiber can take a concentric configuration in which the circular core portion and the doughnut-shaped sheath portion are arranged in concentric
10   relation. Of the above configurations, the concentric sheath-core configuration is preferable. These configurations across the cross section of conjugate fiber will be illustrated in Fig. 3, in which (a) shows a concentric sheath-core arrangement, (b) shows a side-by-side arrangement
15   and (c) shows an islands-in-the-sea arrangement. In these configurations of the conjugate fiber, at least one component in every phase should be in a fiber form. For example, when the aforesaid polymer blends have constituted fiber phases, at least one component of the blend polymer should have a fiber
20   form in every phase and others form a three-dimensional islands-in-the-sea structure within the fiber phase.

Among at least two olefin-based polymers constituting the fiber, the olefin-based polymer having the earliest (shortest) induction period of strain-induced crystallization

is preferably contained in an amount of 1 to 70 wt%, more preferably 1 to 50 wt%, and particularly preferably 1 to 30 wt% of the fiber. When the olefin-based polymer with the earliest induction period of strain-induced crystallization

5   is contained at above 70 wt%, the fiber cannot be beautifully spun. In that the concentric sheath-core conjugate fiber is beautifully spun and the resultant fiber has high extensibility, the core portion preferably comprises the olefin-based polymer having an earlier induction period of

10   strain-induced crystallization.

<Nonwoven fabric>

The extensible nonwoven fabric according to the invention contains the above fiber. Preferably, the extensible nonwoven fabric is a spunbonded nonwoven fabric.

15   The extensible nonwoven fabric preferably has a mass per unit area (basis weight) of 3 to 100 g/m^2, and more preferably 10 to 40 g/m^2. Having this basis weight, the extensible nonwoven fabric will be excellent in softness, touch, conformability to the body, conformity during body movements,

20   drape, economical efficiency and see-through properties.

Preferably, the extensible nonwoven fabric will have an extensibility of not less than 70%, more preferably not less than 100%, even more preferably not less than 150%, and particularly preferably not less than 180% under a maximum load

in the machine direction (MD) and/or in the cross machine

direction (CD). Extensibility of less than 70% can cause

fracture during the processing such as drawing, resulting in

a noticeable loss in fabric strength and fuzzing. Therefore,

5   it will be difficult to achieve satisfactory performances,

such as good touch, when used in disposable diapers and similar

products. Particularly, when the extensible nonwoven fabric

with the basis weight of 10 to 40 g/m^2 has the extensibility

of usually not less than 70%, preferably not less than 100%,

10   more preferably not less than 150%, and particularly

preferably not less than 180%, it will exhibit very excellent

practical properties including touch and body conformity.

Preferably, the extensible nonwoven fabric will have a

fineness of 5.0 denier or less. Having the fineness of not

15   more than 5.0 denier, the nonwoven fabric will have excellent

softness.

The extensible nonwoven fabric may be produced by a

number of commonly known processes. For example, dry spinning,

wet spinning, spunbonding and meltblowing may be employed.

20   The spinning method may be appropriately selected depending

on desired properties of the nonwoven fabric. The spunbonding

method may be preferably used due to its high productivity and

because it can produce highly strong nonwoven fabrics.

Hereinbelow, the method of producing the extensible

nonwoven fabric will be described by reference to a production

of spunbonded nonwoven fabric which contains concentric

sheath-core conjugate fibers comprising two olefin-based

polymers. It should be understood that the production method

5   of the extensible nonwoven fabric is not limited to the

following.

First, two olefin-based polymers will be produced

separately. Herein, the additive(s) may be added to one or

both of the two olefin-based polymers when needed. The

10   olefin-based polymers are molten in a respective extruder or

like means such that the core portion comprises one polymer

and the sheath portion comprises another polymer. Then the

olefin-based polymers are extruded through a spinneret with

conjugate spinning nozzles designed to produce a desired

15   concentric sheath-core configuration. The concentric

sheath-core conjugate continuous fiber thus spun is cooled

with a cooling fluid, then stretched to a predetermined

finesses by drawing air, and deposited on a collecting belt

in a predetermined thickness. The web is then subjected to

20   an entanglement treatment, such as needle punching, water

jetting or ultrasonic sealing, or thermal bonding with a hot

embossing roll. The desired spunbonded nonwoven fabric

comprising the concentric sheath-core conjugate fiber can be

thus obtained. The hot embossing roll used in the thermal

bonding may have an arbitrary embossing area percentage; preferably, the embossing area percentage will be 5 to 30%.

The extensible nonwoven fabric of the invention can be heat-embossed at low temperatures. As a result, fuzzing will

5   rarely take place and wide applications including disposable diapers can be attained. Since he extensible nonwoven fabric of the invention can be embossed at a low temperature, it has an ability of reduction of energy costs in the production.

The extensible nonwoven fabric may be subjected to

10   stretching by a common procedure. Stretching (elongating) in the machine direction (MD) may be performed by passing the extensible nonwoven fabric through two or more sets of nip rolls. In this stretching, each set of nip rolls will be operated faster than the previous set in the machine direction (MD).

15   Further, gear stretching may be performed using stretching gears as shown in Fig. 4.

<Composite nonwoven fabric>

The composite nonwoven fabric according to the invention comprises at least one layer comprising the aforesaid

20   extensible nonwoven fabric. Other layer (hereinafter the "other extensible layer") than the extensible nonwoven fabric contained in the composite nonwoven fabric is not particularly limited at least as long as it has extensibility. Preferably, the other extensible layer comprises an elastic polymer having

both contraction and expansion properties.

The elastic polymers used include elastic materials having extensibility and contractility. Vulcanized gums and thermoplastic elastomers are suitable elastic materials.

5 Particularly, thermoplastic elastomers are preferable due to their excellent formability. The thermoplastic elastomers are high-molecular materials that show elastic properties as do vulcanized rubbers at room temperature (which is due to the soft segments in the molecule) and that can be molded with a

10 common molding machine at higher temperatures likewise with thermoplastic resins (which is due to the hard segments in the molecule).

The thermoplastic elastomers usable in the invention include urethane elastomers, styrene elastomers, polyester

15 elastomers, olefin elastomers and polyamide elastomers.

The urethane elastomers are polyurethanes that are obtained by reaction of polyester or low molecular weight glycol with methylenebisphenyl isocyanate or tolylene diisocyanate. Examples thereof include adducts, such as

20 polyether polyurethanes, resulting from addition polymerization of polyisocyanate to polylactone ester polyol in the presence of short-chain polyols; adducts, such as polyester polyurethanes, resulting from addition polymerization of polyisocyanate to polyol adipate formed from

adipic acid and glycol, in the presence of short-chain polyols;

and adducts obtained by addition polymerization of

polyisocyanate to polytetramethylene glycol resulting from

ring opening of tetrahydrofuran, in the presence of short chain

5   polyols. These urethane elastomers are commercially

available under the trademarks of Resamine (Dainichiseika

Color & Chemicals Mfg. Co., Ltd.), Miractolan (Nippon

Polyurethane Industry Co., Ltd.), Elastolan (BASF), Pandex and

Desmopan (DIC-Bayer Polymer Ltd.), Estene (B.F. Goodrich) and

10   Pellethane (Dow Chemical Company).

The styrene elastomers include styrene block copolymers,

such as SEBS (styrene/(ethylene-butadiene)/ styrene), SIS

(styrene/isoprene/styrene), SEPS

(styrene/(ethylene-propylene)/styrene) and SBS

15   (styrene/butadiene/styrene). These styrene elastomers are

commercially available under the trademarks of Kraton (Shell

Chemicals), Cariflex TR (Shell Chemicals), Solprene (Phillips

Petroleum Co.), Europrene SOL T (Enichem Elastomers), Tufprene

(Asahi Kasei Corporation), Solprene T (Japan Elastomer Co.,

20   Ltd.), JSRTR (JSR Corporation), Denka STR (Denki Kagaku Kogyo

K.K.), Quintac (Zeon Corporation), Kraton G (Shell Chemicals),

Tuftec (Asahi Kasei Corporation) and Septon (Kuraray Co.,

Ltd.).

The polyester elastomers include those containing a hard

segment comprising aromatic polyester and a soft segment comprising non-crystalline polyether or aliphatic polyester. Specific examples include polybutylene terephthalate/ polytetramethylene ether glycol block copolymers.

5   The olefin elastomers include ethylene/α-olefin random copolymers and those obtained by copolymerizing a diene as a third component to the random copolymers. Specific examples include those containing a hard segment comprising polyolefin and a soft segment comprising ethylene/propylene random

10 copolymer, ethylene/1-butene random copolymer, or ethylene/propylene/diene copolymer (EPDM) such as ethylene/propylene/dicyclopentadiene copolymer or ethylene/propylene/ethylidene norbornene copolymer. These olefin elastomers are commercially available under the

15 trademarks of Tafmer (Mitsui Chemicals Inc.) and Milastomer (Mitsui Chemicals Inc.).

      The polyamide elastomers include those containing a hard segment comprising nylon and a soft segment comprising polyester or polyol. Specific examples include Nylon

20 12/polytetramethylene glycol block copolymers.

      Of these, the urethane, styrene and polyester elastomers are preferred. Particularly, the urethane and styrene elastomers are preferred in view of excellent contraction and expansion properties.

The other extensible layer may be contained into various forms, including filament, net, film and foam. These layers can be produced by a common method.

The composite nonwoven fabric according to the invention can be obtained by bonding the layer of the extensible nonwoven fabric and the other extensible layer by a conventional method. The bonding methods include hot embossing, ultrasonic embossing, through hot-air bonding, needle punching, and adhesive bonding.

The adhesives for use in the adhesive bonding include resin adhesives such as vinyl acetate adhesives and polyvinyl alcohol adhesives, and rubber adhesives such as styrene/butadiene adhesives, styrene/isoprene adhesives and urethane adhesives. Solvent adhesives obtained by dissolving the aforesaid adhesives in organic solvents, and aqueous emulsion adhesives obtained from the aforesaid adhesives are also employable. Of these adhesives, the rubber hot melt adhesives, such as styrene/butadiene adhesives and styrene/isoprene adhesives, are preferably used since they do not deteriorate the texture.

The composite nonwoven fabric may be subjected to stretching by a common procedure likewise with the extensible nonwoven fabric.

<Applications>

The extensible nonwoven fabric and the composite nonwoven fabric according to the invention are excellent in extensibility, tensile strength, fuzz resistance, surface abrasion resistance, formability and productivity.

5   Therefore, they can be used in wide industrial applications including medical, hygiene and wrapping products. In particular, they can be suitably used in disposable diapers.

EXAMPLES

10   The present invention will be described by the following Examples, but it should be construed that the invention is in no way limited to the Examples. The measurement and comparison procedures for the induction periods of strain-induced crystallization are described below. Also, the procedures in

15   a tensile test and a fuzz resistance evaluation for the nonwoven fabrics are illustrated.

<Evaluation procedures>

(1) Measurement of induction period of strain-induced crystallization

20   The induction period of strain-induced crystallization was determined at a temperature between the equilibrium melting point and the static crystallization temperature of the polymer. The melt shear viscosity was measured at a constant temperature and a fixed shear strain rate to determine

the induction period of strain-induced crystallization. The

measurement was made first at around the equilibrium melting

point, and when no increase in viscosity was observed within

7200 seconds from the measurement initiation, the measurement

5   temperature was lowered and the melt shear viscosity was

measured again. This procedure was repeated until the

induction period of strain-induced crystallization was

determined within 7200 seconds. The conditions in the

measurement of the melt shear viscosity are given below.

10   Device: ARES Model produced by Rheometrics

Measurement mode: time sweep

Shear rate: 2.0 rad/s

Temperature: 130°C, 140°C, 150°C, 160°C, 170°C

Tool: Cone plate (diameter: 25mm)

15   Measurement environment: nitrogen atmosphere

(2) Comparison of SIC induction periods

The induction period of strain-induced crystallization

of the polymers were compared at the temperature determined

as described below. First, the highest measurement

20   temperature that the induction period of strain-induced

crystallization is determined within 7200 seconds was selected

for each polymer (hereinafter the "selected temperature").

Thereafter, the induction periods of strain-induced

crystallization of the polymers were compared at a comparison

temperature which is the highest temperature among all the

selected temperatures of the polymers employed.

(3) Measurement of melt flow rate

The melt flow rate (MFR) was measured for the polymers

5   in accordance with ASTM D1238. The conditions are as follows:

Polypropylene: 230°C under 2.16kg load

Polyethylene: 190°C under 2.16kg load

(4) Measurement of crystallization temperature

The crystallization temperature was measured by a

10   differential scanning calorimeter (DSC). In the measurement,

the polymer was heated to 200°C at a rate of 10°C/min in a

nitrogen atmosphere, maintained at this temperature for 10

minutes, and cooled to 30°C at a rate of 10°C/min. The

temperature at exothermic peak obtained in the cooling was

15   determined as the crystallization temperature.

Based on the inventors' past experience in this field,

the temperature higher than the crystalline temperature by 20°C

was determined as the static crystallization temperature.

(5) Tensile test

20   Five specimens, each 25 mm in the machine direction (MD)

and 2.5 mm in the cross direction (CD), were extracted from

the nonwoven fabric. Another five specimens, each 2.5 mm in

the MD and 25 mm in the CD, were extracted from the same nonwoven

fabric. The former five specimens were subjected to a tensile

test using a constant extension tensile tester under the

conditions of chucks distance of 100 mm and a stress rate of

100 mm/min. The maximum load in the machine direction, the

extensibility at the maximum load and the elongation at break

5   (no load) were measured for the five specimens and the results

were averaged. With respect to the latter five specimens too,

the maximum load in the cross direction, the extensibility at

the maximum load and the elongation at break were measured in

the tensile test and the results were averaged.

10   (6) Fuzz resistance measurement (brushing test)

The fuzz resistance was determined in accordance with

JIS L1076. Three specimens, each 25 mm in the MD and 20 mm

in the CD, were extracted from the nonwoven fabric. The

specimens were placed on a holder of a tester with brush and

15   sponge. In the test, a felt was used instead of the brush and

sponge, and the specimens were rubbed therewith 200 times at

a rate of 58 rpm. The rubbed specimens were visually observed

and the fuzz resistance was evaluated based on the following

criteria.

20   (Evaluation criteria)

5: no fuzzing

4: little fuzzing

3: some fuzzing

2: noticeable fuzzing but no fracture

1: noticeable fuzzing and fracture

<Polypropylenes>

Polypropylenes (PP1 to PP5) used in Examples and Comparative Examples had the properties illustrated in Table 1.

Table 1

	PP1	PP2	PP3	PP4	PP5
SIC induction period (sec)					
170°C	>7200	>7200	>7200	>7200	>7200
160°C	>7200	>7200	>7200	>7200	>7200
150°C	>7200	>7200	>7200	>7200	>7200
140°C	279	319	399	>7200	>7200
130°C	Not measured	Not measured	Not measured	719	1479
MFR (g/10 min)	15	30	60	60	60
Melting point (°C)	162	162	162	142	138
Mw/Mn	3.0	2.8	2.6	2.8	2.5
Ethylene unit content (mol%)	0	0	0	4	5
Crystallization temperature (°C)	116	116	116	101	94
Static crystallization temperature (°C)	136	136	136	121	114

<Example 1>

PP1 and PP3 were melt spun into conjugate fibers which comprise the core portion of PP1 and the sheath portion of PP3. The resultant conjugate fibers having the concentric sheath-core configuration with a weight ratio of the core

portion to the sheath portion of 10/90 (PP1/PP3) were deposited

on a collecting surface. The deposit was then heated and

pressed with an embossing roll (embossing area percentage: 18%,

embossing temperature: 120°C) to give a spunbonded nonwoven

5   fabric having a basis weight of 25 g/m^2 and a fiber fineness

of 3.5 denier. The spunbonded nonwoven fabric was tested to

determine its properties. The results are shown in Table 2.

<Example 2>

A spunbonded nonwoven fabric was produced with the

10 procedure illustrated in Example 1 except that PP4 was used

in place of PP3 in the sheath portion and that the embossing

temperature was changed from 120°C to 100°C. The spunbonded

nonwoven fabric was tested to determine its properties. The

results are shown in Table 2.

15 **<Example 3>**

A spunbonded nonwoven fabric was produced with the

procedure illustrated in Example 1 except that PP5 was used

in place of PP3 in the sheath portion and that the embossing

temperature was changed from 120°C to 80°C. The spunbonded

20 nonwoven fabric was tested to determine its properties. The

results are shown in Table 2.

<Example 4>

A spunbonded nonwoven fabric was produced with the

procedure illustrated in Example 3 except that PP2 was used

in place of PP1 in the core portion and that the embossing
temperature was changed from 80°C to 100°C. The spunbonded
nonwoven fabric was tested to determine its properties. The
results are shown in Table 2.

5   **<Example 5>**

A spunbonded nonwoven fabric was produced with the
procedure illustrated in Example 1 except that the core/sheath
weight ratio was changed from 10/90 to 20/80 and that the
embossing temperature was changed from 120°C to 100°C. The
10   spunbonded nonwoven fabric was tested to determine its
properties. The results are shown in Table 2.

<Example 6>

A spunbonded nonwoven fabric was produced with the
procedure illustrated in Example 2 except that the core/sheath
15   weight ratio was changed from 10/90 to 20/80 and that the
embossing temperature was changed from 100°C to 80°C. The
spunbonded nonwoven fabric was tested to determine its
properties. The results are shown in Table 2.

<Example 7>

20   A spunbonded nonwoven fabric was produced with the
procedure illustrated in Example 3 except that the core/sheath
weight ratio was changed from 10/90 to 20/80. The spunbonded
nonwoven fabric was tested to determine its properties. The
results are shown in Table 2.

<Example 8>

A spunbonded nonwoven fabric was produced with the procedure illustrated in Example 1 except that PP2 was used in place of PP1 in the core portion and that the core/sheath

5 weight ratio was changed from 10/90 to 20/80. The spunbonded nonwoven fabric was tested to determine its properties. The results are shown in Table 2.

<Example 9>

A spunbonded nonwoven fabric was produced with the

10 procedure illustrated in Example 4 except that the core/sheath weight ratio was changed from 10/90 to 20/80. The spunbonded nonwoven fabric was tested to determine its properties. The results are shown in Table 3.

<Example 10>

15 A spunbonded nonwoven fabric was produced with the procedure illustrated in Example 4 except that the core/sheath weight ratio was changed from 10/90 to 50/50 and that the embossing temperature was changed from 100°C to 70°C. The spunbonded nonwoven fabric was tested to determine its

20 properties. The results are shown in Table 3.

<Example 11>

A spunbonded nonwoven fabric was produced with the procedure illustrated in Example 9 except that PP3 was used in place of PP2 in the core portion. The spunbonded nonwoven

fabric was tested to determine its properties. The results are shown in Table 3.

<Example 12>

A spunbonded nonwoven fabric was produced with the

5 procedure illustrated in Example 1 except that embossing temperature was changed from 120°C to 100°C and that the fiber fineness was altered from 3.5 denier to 2.5 denier. The spunbonded nonwoven fabric was tested to determine its properties. The results are shown in Table 3.

10 **<Example 13>**

A spunbonded nonwoven fabric was produced with the procedure illustrated in Example 5 except that the fiber fineness was altered from 3.5 denier to 2.5 denier. The spunbonded nonwoven fabric was tested to determine its

15 properties. The results are shown in Table 3.

<Example 14>

A spunbonded nonwoven fabric was produced with the procedure illustrated in Example 2 except that the fiber fineness was altered from 3.5 denier to 2.5 denier. The

20 spunbonded nonwoven fabric was tested to determine its properties. The results are shown in Table 3.

<Example 15>

A spunbonded nonwoven fabric was produced with the procedure illustrated in Example 6 except that the fiber

fineness was altered from 3.5 denier to 2.5 denier. The spunbonded nonwoven fabric was tested to determine its properties. The results are shown in Table 3.

<Example 16>

5   A spunbonded nonwoven fabric was produced with the procedure illustrated in Example 3 except that the fiber fineness was altered from 3.5 denier to 2.5 denier. The spunbonded nonwoven fabric was tested to determine its properties. The results are shown in Table 4.

10   **<Example 17>**

A spunbonded nonwoven fabric was produced with the procedure illustrated in Example 7 except that the fiber fineness was altered from 3.5 denier to 2.5 denier. The spunbonded nonwoven fabric was tested to determine its

15   properties. The results are shown in Table 4.

<Example 18>

A spunbonded nonwoven fabric was produced with the procedure illustrated in Example 4 except that the fiber fineness was altered from 3.5 denier to 2.5 denier. The

20   spunbonded nonwoven fabric was tested to determine its properties. The results are shown in Table 4.

<Example 19>

A spunbonded nonwoven fabric was produced with the procedure illustrated in Example 9 except that the fiber

fineness was altered from 3.5 denier to 2.5 denier. The
spunbonded nonwoven fabric was tested to determine its
properties. The results are shown in Table 4.

<Comparative Example 1>

5   PP3 and a polyethylene (PE1) were used as the
olefin-based polymers. The polyethylene (PE1) had MFR, as
measured at 190°C under a load of 2.16 kg in accordance with
ASTM D1238, of 60 g/10 min, a density of 0.93 g/cm^3 and a melting
point of 115°C.

10   A spunbonded nonwoven fabric was produced with the
procedure illustrated in Example 11 except that PE1 was used
in place of PP5 in the sheath portion and that the embossing
temperature was changed from 100°C to 110°C. The spunbonded
nonwoven fabric was tested to determine its properties. The
15   results are shown in Table 4.

<Comparative Example 2>

PP3 alone was melt spun and the monocomponent fiber was
deposited on a collecting surface. The deposit was then heated
and pressed with an embossing roll (embossing area percentage:
20   18%, embossing temperature: 130°C) to give a spunbonded
nonwoven fabric having a basis weight of 25 g/m^2 and a fiber
fineness of 3.5 denier. The spunbonded nonwoven fabric was
tested to determine its properties. The results are shown in
Table 5.

<Comparative Example 3>

A spunbonded nonwoven fabric was produced with the procedure illustrated in Comparative Example 2 except that PP4 was used in place of PP3.   The spunbonded nonwoven fabric was

5   tested to determine its properties.   The results are shown in Table 5.

<Comparative Example 4>

A spunbonded nonwoven fabric was produced with the procedure illustrated in Comparative Example 2 except that the

10   fiber fineness was altered from 3.5 denier to 2.5 denier.   The spunbonded nonwoven fabric was tested to determine its properties.   The results are shown in Table 5.

<Comparative Example 5>

A spunbonded nonwoven fabric was produced with the

15   procedure illustrated in Comparative Example 2 except that the embossing temperature was changed from 130°C to 80°C.   The spunbonded nonwoven fabric was tested to determine its properties.   The results are shown in Table 5.

Table 2

		Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6	Ex. 7	Ex. 8
Core portion (A)									
Resin		PP1	PP1	PP1	PP2	PP1	PP1	PP1	PP2
SIC induction period (140°C) (sec)		279	279	279	319	279	279	279	319
MFR (g/10 min)		15	15	15	30	15	15	15	30
Melting point (°C)		162	162	162	162	162	162	162	162
Sheath portion (B)									
Resin		PP3	PP4	PP5	PP5	PP3	PP4	PP5	PP3
SIC induction period (140°C) (sec)		399	>7200	>7200	>7200	399	>7200	>7200	399
MFR (g/10 min)		60	60	60	60	60	60	60	60
Melting point (°C)		162	142	138	138	162	142	138	162
Core/Sheath weight ratio (A/B)		10/90	10/90	10/90	10/90	20/80	20/80	20/80	20/80
Embossing temperature (°C)		120	100	80	100	100	80	80	120
Fiber fineness (d)		3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Basis weight (g/m^2)		25	25	25	25	25	25	25	25
Extensibility at maximum load (%)	MD	191	201	177	123	157	186	192	80
	CD	161	177	163	124	92	156	140	60
Elongation at break (%)	MD	199	221	187	132	167	201	202	93
	CD	169	185	176	134	125	176	158	82
Fuzz resistance		5	5	5	5	5	5	5	5

Table 3

		Ex. 9	Ex. 10	Ex. 11	Ex. 12	Ex. 13	Ex. 14	Ex. 15
Core portion (A)								
Resin		PP2	PP2	PP3	PP1	PP1	PP1	PP1
SIC induction period (140°C) (sec)		319	319	399	279	279	279	279
MFR (g/10 min)		30	30	60	15	15	15	15
Melting point (°C)		162	162	162	162	162	162	162
Sheath portion (B)								
Resin		PP5	PP5	PP5	PP3	PP3	PP4	PP4
SIC induction period (140°C) (sec)		>7200	>7200	>7200	399	399	>7200	>7200
MFR (g/10 min)		60	60	60	60	60	60	60
Melting point (°C)		138	138	138	162	162	142	142
Core/Sheath weight ratio (A/B)		20/80	50/50	20/80	10/90	20/80	10/90	20/80
Embossing temperature (°C)		100	70	100	100	100	100	80
Fiber fineness (d)		3.5	3.5	3.5	2.5	2.5	2.5	2.5
Basis weight (g/m²)		25	25	25	25	25	25	25
Extensibility at maximum load (%)	MD	123	81	95	149	141	174	170
	CD	178	50	89	103	101	140	143
Elongation at break (%)	MD	131	128	102	167	171	183	175
	CD	192	112	108	127	135	158	159
Fuzz resistance		5	5	5	5	5	5	5

Table 4

		Ex. 16	Ex. 17	Ex. 18	Ex. 19	Comp. Ex. 1
Core portion (A)						
Resin		PP1	PP1	PP2	PP2	PP3
SIC induction period (140°C) (sec)		279	279	319	319	399
MFR (g/10 min)		15	15	30	30	60
Melting point (°C)		162	162	162	162	162
Sheath portion (B)						
Resin		PP5	PP5	PP5	PP5	PE1
SIC induction period (140°C) (sec)		>7200	>7200	>7200	>7200	—
MFR (g/10 min)		60	60	60	60	60 (190°C)
Melting point (°C)		138	138	138	138	115
Core/Sheath weight ratio (A/B)		10/90	20/80	10/90	20/80	20/80
Embossing temperature (°C)		80	80	100	100	110
Fiber fineness (d)		2.5	2.5	2.5	2.5	3.5
Basis weight (g/m²)		25	25	25	25	25
Extensibility at maximum load (%)	MD	164	129	116	119	157
	CD	138	188	160	144	157
Elongation at break (%)	MD	173	142	123	128	169
	CD	154	197	169	155	172
Fuzz resistance		5	5	5	5	1

Table 5

		Comp. Ex. 2	Comp. Ex. 3	Comp. Ex. 4	Comp. Ex. 5
Resin		PP3	PP4	PP3	PP3
SIC induction period (140°C) (sec)		399	>7200	399	399
MFR (g/10 min)		60	60	60	60
Melting point (°C)		162	142	162	162
Embossing temperature (°C)		130	130	130	80
Fineness (d)		3.5	3.5	2.5	3.5
Basis weight (g/m^2)		25	25	25	25
Extensibility at maximum load (%)	MD	47	69	26	22
	CD	39	55	35	29
Elongation at break (%)	MD	61	75	50	72
	CD	64	60	56	91
Fuzz resistance		5	5	5	1

\<Example 20\>

      PP1 and PP3 were melt spun into conjugate fibers which comprise the core portion of PP1 and the sheath portion of PP3. The resultant conjugate fibers having the concentric

5   sheath-core configuration with a weight ratio of the core portion to the sheath portion of 10/90 (PP1/PP3) were deposited on a collecting surface. Thereon, SEPS (styrene/(ethylene-propylene)/styrene) block copolymer (trade name: SEPS 2002 available from Kuraray Co., Ltd.) was

10   spread by a common meltblowing process to produce a laminate. Thereafter, PP1 and PP3 were melt spun into a concentric sheath-core conjugate fibers, and the resultant fibers were deposited on the above-obtained laminate. The concentric sheath-core conjugate fibers had the core portion of PP1 and

15   the sheath portion of PP3 with a core/sheath weight ratio of 10/90. The resultant laminate (web) was then heated and pressed with an embossing roll (embossing area percentage: 18%, embossing temperature: 120°C) to give a spunbonded/meltblown/spunbonded nonwoven fabric having a

20   basis weight of 130 g/m^2.

      A 50mm wide specimen was extracted from the nonwoven fabric. The specimen was elongated to 180% of its original length by means of a tensile tester and thereafter relaxed to 0% elongation. The stress-strain curve obtained in the test

is shown in Fig. 5. Thereafter, the specimen was again

elongated to 180% of its original length and thereafter relaxed

to 0% elongation. The stress-strain curve obtained in this

second test is shown in Fig. 6. There ware no filament fracture

5   or the like in the spunbonded nonwoven fabric layer after the

tensile tests. The fuzz resistance test resulted in the

evaluation of 5.

INDUSTRIAL APPLICABILITY

10   The invention provides an extensible nonwoven fabric and

a composite nonwoven fabric comprising the extensible nonwoven

fabric, both being excellent in extensibility, tensile

strength, fuzz resistance, surface abrasion resistance,

formability and productivity. They can be used in wide

15   industrial applications including medical, hygiene and

wrapping products. In particular, they can be suitably used

in disposable diapers due to their comfortable touch

attributed to excellent fuzz resistance.